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Influence of the extraction process on the chemical composition and oxidation state of baobab (*Adansonia digitata* L.) seed oil

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Baobab oil is nowadays highly prized by local populations as well as the cosmetic industry. It is a rare oil due to the low oil content of the seeds of the baobab fruit (*Adansonia digitata* L.). To obtain this oil, the collected seeds were cleaned and ground into powder. Then, the extraction was done by pressing and solvent. The aim of this study is to assess the impact of the extraction method on the composition of baobab oil. According to the results obtained, the solvent extraction process has an influence on the fatty acid composition, especially for oleic (36.42 vs 37.40) % and linoleic (26.85 vs 25.21) % acids. We note a significant difference in the total sterol in favor of the solvent extraction process (370.02 mg.100.g^{-1} for the oil obtained by pressing against 458.14 mg.100.g^{-1} for the oil obtained by solvent). Solvent extraction drastically reduces total tocopherols from 1562.4 mg.kg^{-1} to 547.6 mg.kg^{-1}. The chlorophyll content decreases slightly. However, the carotenoid content increases slightly with solvent extraction. According to the results obtained, the soxhlet solvent extraction process has an effect on the chemical composition of the oil. The heat contributes to the oxidation of the oil and the reduction of sensitive elements such as tocopherols.

Keywords: Adansonia digitata *L.*, baobab oil, chemical composition, oxidative stability, seeds, Extraction methods, Fatty acid composition, Sterol content, Tocopherols, Chlorophyll content, Carotenoid content, Soxhlet solvent extraction.

INTRODUCTION

The baobab (*Adansonia digitata L.*) is an emblematic tree of the savannah, characteristic of Sahelian zones (Diop *et al.,* 2006, Alioune *et al.,* 2018). It belongs to the Bombacaceae family and the order Malvales. The fruit is surrounded by a brownish, highly lignified epicarp and contains black to brown seeds covered by a whitish pulp, all surrounded by a cloud of reddish-brown fibres (Diop *et al.,* 2006). The seeds, which make up more than half of the mass of the dehusked fruit, have so far been under-exploited compared to the pulp (Alioune *et al.,* 2018, Cisse *et al.,* 2018). These seeds were used as a thickening agent in sauces, as a flavouring agent when fermented or roasted and eaten as snacks (Kaboré *et al.,* 2011). Today they are highly prized because of the lipids they contain (12.2%) (Alioune *et al.,* 2018). Indeed, baobab seed oil is rich in polyunsaturated fatty acids, sterols, and tocopherols (Cisse *et al.,* 2009, Kamatou *et al.,* 2011, Alioune *et al.,* 2018, Buchmann *et al.,* 2010). The valorization of baobab fruit, in particular, its seeds, has increased the purchasing power of local populations and fought against poverty in rural areas. Baobab seed oil has a number of medicinal uses, including wound healing and skin softening and regeneration Sow, 2019. In ethnopharmacological studies, baobab seed oil was found to possess several biological functions, such as antioxidant, anti-inflammatory, antidiarrheal, antipyretic, analgesic, and excipient (Ibrahim *et al.,* 2014), possibly due to the presence of tocopherols, which act as lipophilic phenolic antioxidants and protect polyunsaturated fatty acids from lipid peroxidation in the body, where reactive oxygen species may come from environmental exposure or are formed as side products of cell

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metabolism (Delgado *et al.*, 2020). The Codex Alimentarius defines cold-pressed oils as oils obtained, without altering the nature of the oil, exclusively by mechanical processes such as expulsion or pressing, without the use of thermal processes. They may have been purified solely by washing with water, decanting, filtering and centrifuging (Alimentarius, 1999). Indeed, extraction by pressing of baobab oil gives a very low yield of about 4 to 6% (Alioune *et al.*, 2018, Cisse *et al.*, 2018). Most of the oil is found in the extraction cake. Thus, to maximize the yield, extraction of oil from baobab seeds, extraction is carried out with organic solvent (hexane) in soxhlet to remove the most of the oil contained in the seeds (Kaboré *et al.*, 2011, Birnin-Yauri and Garba, 2011). In this step, the paste is sterilized, lipases and other deleterious enzymes are inactivated, the cell walls are softened to facilitate oil extraction, and elasticity is obtained to ensure efficient pressing (Issaoui and Delgado, 2019). To the best of our knowledge, no study has been performed on the effect of oil extraction process on the chemical composition of baobab oil, and also there is a lak of information on sterol and tocopherol content and composition of baobab oil.

The objective of this study was to investigate the impact of the baobab seed oil extraction process on its chemical composition (fatty acids, sterols and tocopherols) and oxidative stability by determining the quality indices, specific extinction coefficients at 232 and 270 nm, and carotenoid and chlorophyll contents of the extracted oil.

MATERIALS AND METHODS

***Plant material*:** The plant material consisted of seeds from fruit of baobab (*Adansonia digitata* L.), dehulled and depulped from fruits collected at random in the region of Tambacounda, Senegal (latitude: 13°46′14″ North; longitude 13°40′02″west). The production of the oil required a total mass of 100 kg of seeds divided into two batches. Thus, a first batch of 90 kg of seeds is subdivided into three parts for oil extraction with press. The second batch consists of 10 kg of seeds for soxhlet extraction. The Fig. 1 presents the baobab fruit (*Adansonia digitata* L.)

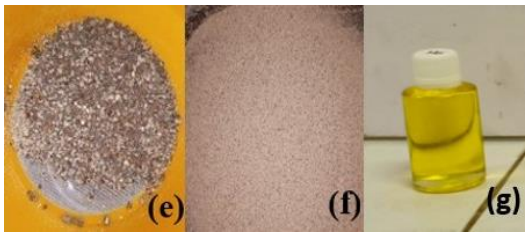

Figure 1. Entire fruit (a), opened fruit (b), seeds wrapped in pulp (c), seeds without pulp (d), crushed seeds (e), crushed almond seeds (f) and baobab fruit seed oil (g).

OIL EXTRACTION METHODS

***Cold press extraction*:** The baobab seeds are first cleaned, then spread out on a table and dried in the sun before being ground in a millet mill with a capacity of 300 to 350 $kg.h^{-1}$ with an electric motor power estimated at 7.5 HP, equipped with sieves with holes of 1 mm diameter at a speed of 2800 rpm. The resulting powder is collected in a basin. 25 kg of this powder is pressed with a KOMET, DD85G type press, IBG Monforts Ockotec GmbH, Germany **(Figure 2)**. The pressing is carried out on three times 25 kg of the seed powder. The press is equipped with a 10 mm die with a rotation speed of 25 rpm. The outlet head was heated to 105 °C for 25 min at the beginning of the extraction. Thus, the crude oil obtained is mixed with impurities. It is therefore left to decant for several days and then filtered under pressure using special cloth filters to give light yellow oil. The extracted oil is stored at 4 °C in 30 mL glass vials prior to the start of initial and follow-up analyses.

Figure 2. Electric press KOMET D85.

***Soxhlet extraction*:** The solvent extraction is carried out with hexane in a Soxhlet (Fig. 3). In the laboratory, the 10 kg of pulped seeds are dried in an oven at 65 °C for 24 hours before being crushed using an aluminium mortar and pestle. After

this stage, the crushed seeds are ground in a laboratory-type electric mill (MONBROY, BMS-6). The oil was extracted using a Soxhlet according to the international standard (2009). For this, 30 g of baobab seed powder introduced into a cartridge is placed in the extractor. The sample quickly comes into contact with 240 mL of hexane, allowing the transfer equilibrium to be shifted to the solvent. This is repeated continuously (8 hours) giving a mixture of solvent and oil. Finally, the solvent containing the lipids is then evaporated under reduced pressure using a rotary evaporated at 67 °C. The extraction is repeated several times. The resulting oil is packaged in 30 mL glass vials and stored at 4 °C before the start of the initial analyses.

Figure 3. Soxhlet extraction system.

***Physicochemical properties of Baobab oils Color value*:** Colorimetry is a process by which it is possible to find the degree of absorbance of light by the liquid. The color value or yellowness allows us to assess the quality of the oil′s color. The measurement of this index noted Y1 is well adapted to evaluate the state of degradation of an oil, exposed to heat, light or another environment. It is determined according to the method adopted by Sow *et al.* (2019). The sample of liquid oil is poured into the cell with sufficient optical path length for the defined ranges and then the cell is placed in the light box near the observation tube. Then the cover of the light box is closed and the color of the sample is determined using a color representation model. The yellowness index is read directly from the colorimeter (CM-5, Konica Minolta sensing Americas inc., US).

***Quality Parameters**:* Acid value (AV), Peroxide value (PV), Iodine value (IV) and extinction coefficients (E232 and E270) were determined according to AOCS recommended practices Ca 5a-40, Cd 8b-90, Cd 1c-85, and Ch 5e-91, respectively (AOCS, 1998).

***Acid value (AV)*:** The acidity is measured by simple acid-base dosage where mixture (ethanol/diethyl ether) (v/v) is added to the oil, neutralized by a solution of ethanolic potassium hydroxide (0.1N). Acid value content was expressed as mg $KOH.g^{-1}$ of oil.

***Peroxide value*:** To determine the peroxide value, a mixture of oil and (iso-octane/acetic acid) was left in the dark to react with a solution of KI; the free iodine was then titrated with a sodium thiosulfate solution ($Na_2S_2O_3$). PV was expressed in milliequivalents of active oxygen per gram ($mEqO_2.Kg^{-1}$).

***Iodine value (IV)*:** This analysis is based on the oils dilution in a solution of chloroform and iodine bromide, followed by incubation in a dark place at room temperature for 30 minutes. Potassium iodine and water are then added and then the mixture is titrated by sodium thiosulphate. IV was expressed as mg I2/100g of oil,

***Specific extinction value (E232 and E270)*:** The oil is dissolved in cyclohexane and measured at 232 and 270 nm. Extinction coefficient (E232 and E270) was expressed as the specific extinction of a 1% (w/v) solution of oil in cyclohexane in 1 cm cell path length, using an LLG-uniSPEC 2 UV spectrometer.

***Fatty acid composition*:** The fatty acid composition of the oil samples was determined according to the ISO standard (5508, 1990). 0.60 g of oil and 4 ml of iso-octane were added to 5 mL screw-top tubes and 0.20 mL of KOH (2N) methanolic solution was added. The methyl esters were extracted with hexane. Aliquots (1 µL) were injected into the gas chromatograph (Varian CP-3800, varian Inc.) equipped with a GC-FID. The column used was a CP-Wax 52CB capillary column (30m x 0.25mm diameters). Helium is the carrier gas and is injected with a total flow rate of 1 $mL.min^{-1.}$ The initial column temperature was increased in steps of 4 °$C.min^{-1}$. The temperature of the injector and detector is 230 °C. The sample injection volume was 2 mL in split mode (split ratio 1:50). The results were expressed as relative percentage of the area of each fatty acid peak. Data were processed with Varian Star Workstation v 6.30, software (Varian Inc., Walnut Creek, California, USA).

***Sterols composition*:** Chromatographic analysis of sterols transformed into silylated derivatives by a mixture of pyridine, hexamethyldisilazane (HMDS) and trimethyl-chloresilane (TMCS), (v/v/v) was carried out according to ISO standard (1991). After the preparation of the unsaponifiable matter, the sterols obtained, are in turn transformed into silylated derivatives (TMS). The pyridine is evaporated to dryness and the silylated derivatives are diluted with 60 µL of heptane. The sterols were analyzed by gas chromatography (GC) on a capillary column (chroma pack) (30m × 0.32 mm, internal diameter: 0.25 mm, phase: CPSIL8CB). The Hp Hewlett Packard 6890 series GC system is equipped with a GC-FID detector (300°C). The carrier gas

is nitrogen, and its flow rate is 1 mL.min^{-1} (pressure: 8.6 bars). The temperature is programmed from 200 to 270 °C with a speed of 10 °C.min^{-1} and an isotherm at 270 °C for 35 min.

***Tocopherols composition*:** The tocopherol composition of the baobab oil samples was determined according to the method written by Gharby *et al.,* (2018). A solution prepared by mixing 250 mg of baobab oil with 25 mL of n-heptane was used. Tocopherols were analyzed by HPLC on a silica column (25 cm×4 mm). Detection was performed using a fluorescence detector with excitation and detection wavelengths of 290 and 330 nm, respectively. A 99:1 (v/v) isooctane/isopropanol mixture was used as eluent with a flow of 1.2 mL.min^{-1}.

***Determination of chlorophylls and carotenoids*:** The chlorophyll and carotenoid content of baobab oil was determined by UV spectrophotometer measurement according to the method described by Gharby *et al.* (2018). The oil sample to be analyzed was prepared at 1% in cyclohexane. Then, the 1 cm quartz cuvettes are filled with the prepared solution. The blank contains only cyclohexane. Absorbance measurements are made using a spectrophotometer at wavelengths of 670 nm for chlorophylls and 470 nm for carotenoids. The specific extinction values are 613 and 2000 respectively for pheophytin (major component in the chlorophyll fraction) and (major component in the carotenoid fraction). The pigment content is determined as follows:

$$\text{Chlorophyll (mg. Kg}^{-1}) = \frac{(A_{670} \times 10^6)}{(613 \times 100 \times d)} \quad \text{(Eq. 1)}$$

$$\text{Carotenoid (mg. Kg}^{-1}) = \frac{(A_{470} \times 10^6)}{(2000 \times 100 \times d)} \quad \text{(Eq. 2)}$$

Where "A" is the absorbance and "d" is the thickness of the spectrophotometer cell (1 cm). Results are expressed as milligram of pheophytin and lutein per kilogram of oil, respectively.

***Statistical analyses*:** One-way analyses of variance (ANOVA) and Fischer's LSD test at the 5% significance level were performed. The results obtained represent the average of three analyses and the STATISTICA software (version 7.1) was used.

RESULTS AND DISCUSSION

To assess the impact of the extraction process on the quality of the oil, we analyses two samples of baobab oil from the same batch of fruit (Table 1).

Table 1. Physicochemical quality parameters of cold press and solvent extracted baobab oil.

	Cold press-extracted	Solvent-extracted
Extraction yield (%)	5.30^{a}±0.05	11.71^{b}±0.12
Yellowing index	85.20^{a}±0.05	90.30$^{a\pm}$0.02
Acid value (mg KOH/g)	0.50^{a}±0.06	1.34^{b}±0.01
Peroxide value (mEqO_2 /Kg)	0.50^{a}±0.00	2.73^{b}±0.27
Iodine value (mgI_2/100g)	89.00^{a}±1.39	91.00^{a}±0.24
K232	1.05^{a}±0.08	1.13^{b}±0.06
K270	0.15^{a}±0.03	0.29^{b}±0.06

Results are expressed as average ± standard deviation (n= 3); values with same superscript letters within the rows do not differ significantly ($p<0.05$)

***Effect of extraction process on Physico-chemical characterization of baobab oil*:** The extraction yield of the oil contained in baobab seeds is 5.30 % for the oil obtained by pressing against 11.71 % for that obtained by solvent. Cisse *et al.* (2018) had found an extraction yield of 6.28 % for the oil obtained by pressing against 30.29 % for that obtained by solvent. Thus, for Sow *et al.* (2019) the extraction yield of baobab seed oil from the department of Koungheul was 11.79 %. In sum, the extraction process exerts a significant difference ($p<0.05$) on oil yield. Indeed, the pressing process only extracts about 4 to 5 % of the oil contained in baobab seeds (Sow *et al.*, 2019). The oil cakes obtained still contain residual oil. However, thanks to its polar properties, which give it a high affinity for lipids, and its low latent heat of vaporization, 330 kJ.kg^{-1}, which allows it to be evaporated easily and extensively with low energies (Fine *et al.*, 2013), hexane made it possible to obtain twice the oil yield. However, hexane, which was once the preferred solvent for oil seed extraction, is now being questioned because of its toxicity to the nervous system and its flammability in favor of agro-solvents (Fine *et al.*, 2013).

The color, acid, peroxide, and iodine indices are characteristic indices of the physico-chemical quality of vegetables oils (Dandjouma *et al.*, 2008). The yellowing and iodine indices of baobab oil are respectively the same (85.2 vs 90.3; 89 mg (I_2)/100g vs 91 mg (I2)/100g) whatever the extraction process. Cisse *et al.*, (2018) had found for baobab seed oil obtained by pressing a yellowing index equal to 89.64 and 99.11 mg (I_2)/100g for the iodine index against 84.10 and 90.77 mg (I_2)/100g for the oil extracted by hexane. However, there is a significant difference in the acidity ($p<0.05$), peroxide value, and specific extinction (K232 and K270) between the two baobab oil samples.

The acid value of the oil obtained by pressing and that obtained by solvent is (0.50 versus 1.34 mg (KOH).g^{-1}). These results show that solvent extraction slightly increases the acidity of the oil (table 1). This could be due to the fact that during the elaboration of the oil, it is very difficult to avoid the presence of very small amounts of water in the triglyceride mixture (Harhar *et al.*, 2011). Indeed, the results indicate that the oil samples are of good quality since they did not exceed the maximum limit of 4 mg KOH/g of oil according to the Codex Alimentarius Commission (2015). A chemical transformation (hydrolysis), induced by heat (Soxhlet extraction). Slowly leads to the formation of free fatty acids (Harhar *et al.*, 2011, Gharby *et al.*, 2018). However, these

results are contradicted by the work of Cisse *et al.* (2018). Indeed, the authors had found an acid value of 18.82 mg (KOH).g^{-1} for baobab seed oil against 12.44 mg (KOH).g^{-1} for that extracted with hexane.

The peroxide value evaluates the hydroperoxide content and gives an idea of the oxidation state of the lipids. The values of the peroxide indices found for the oil obtained by pressing (0.5 meqO_2.Kg^{-1} of oil) and for that extracted by hexane (2.73 meqO_2.$Kg^{-1}$of oil) are very satisfactory and show a low oxidation of the oil obtained by pressing (Table 1). These results are lower than those found by Cisse *et al.* (2018) (2.09 meqO_2.Kg^{-1} versus 3.17 meqO_2.Kg^{-1}). However, there is a significant difference ($p<0.05$) between the two baobab oil samples, which explains that the extraction process has an impact on the oxidation of the oils. Indeed, high hydroperoxides. When the PV is between 20 and 40 meq O_2/Kg, edible oils typically begin to taste rancid (Vanhanen and Savage, 2006). The main oxidation reactions of lipids are complex, but well known (Cuvelier and Maillard, 2013). They constitute a series of chain reactions that lead to the accumulation of hydroperoxides (LOOH). Effect of extraction process on Fatty acid composition.

Table 2. Fatty acid composition of Baobab oil.

Fatty acid (%)	Cold press-extracted	Solvent-extracted
Myristic acid C14:0	0.17±0.005[a]	0.19±0.005[a]
palmitic acid C16:0	22.01±0.320[a]	23.16±0.350[a]
Palmitoleic acid C16:1	0.26±0.006[a]	0.32±0.007[a]
Stearic acid C18:0	4.32±0.150[a]	4.31±0.140[a]
Oleic acid C18:1	36.43±0.410[a]	37.40±0.400[b]
Linoleic acid C18:2	26.85±0.360[a]	25.20±0.300[b]
Linolenic acid C18:3	0.27±0.005[a]	0.21±0.006[a]
Arachidic acid C20:0	1.03±0.080[a]	0.95±0.050[a]
Gadoleic acid C20 :1	0.25±0.007[a]	0.20±0.006[a]
Other	1.60±0.050[a]	1.50±0.060[a]
SFA	27.52	28.59
MUFA	36.91	37.92
PUFA	27.10	25.41

SFA-Saturated Fatty acids, MUFA-Monounsaturated fatty acids, PUFA-Polyunsaturated fatty acids. Results are expressed as average ± standard deviation (n= 3); values with same superscript letters within the rows do not differ significantly ($p<0.05$)

The fatty acid composition is a key indicator of the nutritional value of the oil (Gharby *et al.*, 2018). The composition analysis allows distinguishing three saturated fatty acids (palmitic, stearic and arachidic acid) and three unsaturated fatty acids (oleic, linoleic and α-linoleic acid) in the majority (table 2). These results compared to those obtained by Gharby *et al.* (2018) allows us to see that baobab oil is richer in linoleic acid 26.85%) than olive oil (9.21%), palmitic acid (22.01 *vs* 10.3% for olive oil) and less rich in oleic acid (36.43 *vs* 75.2) %. Our results are in agreement with those found by Razafimamonjison *et al.* (2017) for baobab oil from different countries in Africa. Thus, whatever the type of extraction (pressing or solvent), the fatty acid composition of the two baobab oils is very close. The only significant difference ($p<0.05$) noted between these two oil samples is in oleic (36.43 vs 37.4) % and linoleic (26.85 vs 25.2) % unsaturated fatty acids, which are the majority fatty acids in baobab oil. This could be due to the effect of heat (solvent extraction) triggering the unsaturation degradation reactions. From these results, we can say that the solvent extraction process does not have a major effect on the fatty acid composition of baobab oil. We note a fraction of fatty acids (1.6 and 1.5%) not elucidated. These results confirm the good fatty acid stability of baobab oil.

Effect of extraction process on Sterol composition.

Table 3. Sterol composition (mg/100g) of the baobab oil samples analyzed.

	Cold press-extracted	Solvent-extracted
Total sterols	370.02±1.290[a]	458.17±1.520[b]
Cholesterol	0.74±0.006[a]	1.65±0.009[a]
Campesterol	32.04±0.110[a]	35.92±0.100[b]
Stigmasterol	9.58±0.040[a]	13.65±0.030[b]
Beta-sitosterol	292.87±0.510[a]	361.54±0.540[a]
Δ 5 avenasterol	12.65±0.070[a]	16.04±0.070[a]
Δ 7 stigmasterol	3.92±0.020[a]	4.49±0.010[a]
Δ 7 avenasterol	2.44±0.005[a]	2.19±0.004[a]
Not identified	15.76±0.020[a]	22.50±0.030[a]

Results are expressed as average ± standard deviation (n= 3); values with same superscript letters within the rows do not differ significantly ($p<0.05$)

The interest of sterols is mainly nutritional, and they limit the polymerization of oils. Phytosterols are currently of great scientific and commercial interest with the development of functional foods and the enrichment of foods with phytosterols (Aïssi *et al.*, 2009). Table 3 shows the sterol composition of the baobab oils. Chromatographic analysis shows that baobab oil is sterol diverse. Among these sterols, the β-sitosterol fraction is more represented with (292.87-361.54) mg.$100g^{-1}$ of the total composition followed by those of campesterol, (32.04-35.92) mg.$100g^{-1}$, Δ5-avenasterol (12.65-16.04) mg.$100g^{-1}$ and Δ7-stigmasterol (3.92-4.49) mg.$100g^{-1}$. Note the presence of an unidentified proportion of sterols. These results compared to those obtained for cactus oil and argan oil (Gharby *et al.*, 2012, 2020), show that baobab oil is richer in sterols than those oils extracted by hexane. Our results show that hexane extraction has no negative influence on the sterol composition of the oil. On the contrary, hexane extraction gave higher total sterol contents (458.17 mg.$100g^{-1}$ obtained with hexane against 370.02 mg.$100g^{-1}$ by pressing).

***Effect of extraction process on Tocopherol composition*:** Tocopherols, components of the unsaponifiable fraction, constitute the class of vitamin E and are very important in oil because they contribute to the stability of the latter. Indeed, thanks to their antioxidant power, they inhibit lipid peroxidation (BenTekaya and Hassouna, 2007).

Due to their role in protecting polyunsaturated fatty acids from oxidative degradation in plant material, tocopherols play an essential role (Alaoui *et al.,* 2016). It is believed that tocopherols contain vitamin E- activity. Free radicals are captured by this vitamin, which neutralizes destructive oxidation [Chatoui *et al.*, 2020].

Table 4. Total Tocopherols and Tocopherol composition of Baobab oil.

Tocopherols (mg/kg)	Cold press-extracted	Solvent-extracted
Total Tocopherols	1562.40±1.94^{a}	547.60±0.86^{b}
α-tocopherol	23.45±0.03^{a}	7.45±0.02^{a}
γ-tocopherol	1438.50±0.15^{a}	504.34±0.18^{a}
δ-tocopherol	100.46±0.07^{a}	30.88±0.06^{b}

Results are expressed as average ± standard deviation (n= 3); values with same superscript letters within the rows do not differ significantly ($p<0.05$)

The HPLC assay revealed that the tocopherol concentration of the oil extracted by press (1562.4 mg.kg-1) is about three times higher than that of the oil obtained by hexane (547.6 mg.kg-1). γ-tocopherol is the main tocopherol (1438.50 vs 504.34 mg.kg^{-1}) followed by δ-tocopherol (100.46 vs 30.88 mg.kg^{-1}) and finally comes l'α-tocopherol (23.45 vs 7.45 mg.kg^{-1}) (table 4). This high content of tocopherols may indicate potential uses for the oil in industrial, nutritional, pharmaceutical, and cosmetic applications (Nyam *et al.,* 2009). Bianchini *et al.* (1982) also found that the principal tocopherol is γ-isomer (59%), but in contrary of our results (Absence of β-tocopherol) they found that baobab oil contains 12% of β-tocopherols. Comparing our results to other oils, baobab oil is richer in tocopherol than argan, cactus and olive oil.

It can be noted that total tocopherol decreases when extracting with solvent, this decrease is probably due to the high temperature used for solvent extraction, Anjum *et al.* (2006) suggest that temperature and roasting time influence the tocopherol content in oils, Our results are consistent with those described in the literature for argan oil (Harhar *et al.,* 2011). These results also are in agreement with those found by Gharby *et al.* (2018). Indeed, the authors had found a decrease in α-tocopherol content with roasting (93.7 à 91.7 mg.kg^{-1}). These results show that solvent extraction degrades tocopherols which, like most vitamins, are sensitive to heat.

Determination of oil pigments

Table 5. Determination of chlorophyll and carotenoid in baobab oil.

	Cold press-extracted	Solvent-extracted
Chlorophyll (mg/kg)	0.80±0.01^{a}	0.61±0.01^{b}
Carotenoids (mg/kg)	0.25±0.02^{a}	0.26±0.02^{b}

Results are expressed as average ± standard deviation (n= 3); values with same superscript letters within the rows do not differ significantly ($p<0.05$)

UV spectrophotometer analysis in cyclohexane at 670 and 470 allowed us to determine the chlorophyll and carotenoid contents of our oils. The results obtained, presented in table 5, showed a significant difference between our two samples of oils analyzed. The concentration of chlorophyll decreased from 0.80 mg.kg^{-1} for the oil extracted by pressing to 0.61 mg.kg^{-1} for that extracted by solvent. On the other hand, carotenoids increased with solvent extraction, from 0.25 for the oil extracted by pressing to 0.26 mg.kg^{-1} for that obtained by solvent. These minor compounds give the oils their organoleptic and nutritional qualities. In addition, these compounds have significant effects on the stability of this product during storage. Indeed, chlorophylls *a* and *b* and their immediate degradation products, phenophytins *a* and *b*, are photosensitisens (Ben Tekaya *et al.,* 2007). According to Ben Tekaya *et al.* (2007), these pigments, in the presence of light change from their singlet ground state to an excited singlet state and then to a metastable triple excited. These pigments tend to revert to their singlet ground state, and this is achieved by converting atmospheric oxygen ($^{3}O_2$) into highly reactive singlet oxygen ($^{1}O_2$). In contrast, the carotenoids (beta-carotene), act as a protector by deactivating the singlet oxygen produced by chlorophylls (BenTekaya and Hassouna, 2007).

***Conclusion*:** The results obtained show that the cold pressed oil retains its physico-chemical properties at best and contains a very high content of tocopherols. Solvent extraction has no effect on the color of the oil nor on the iodine value. However, it does lead to a slight increase in the amount of free fatty acids, peroxides, carotenoids, and primary and secondary oxidation products. In addition, this study showed that the total sterol of baobab seed oil increased with solvent extraction, while the tocopherol composition decreased drastically. The hexane extraction process would certainly destroy the heat-sensitive vitamin E. despite the significant differences noted on some parameters, the solvent extracted baobab oil still complies with the standers established by the Codex Alimentarius on named oils.

***Conflicts of Interest*:** The authors declare that there are no conflicts of interest regarding the publication of this article.

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